PCS Applications

Outputs

- Self-interference models for current and proposed PCS technologies.
- Technical contributions to an industry-developed inter-PCS interference standard for predicting, identifying, and alleviating interference related problems.

Personal Communications Services (PCS) has become an important resource for establishing emergency communication services following natural or man-made catastrophes. Such disasters can damage the wireline telecommunication system, forcing users to migrate to cellular resources. This sudden influx of traffic by private, commercial, civil, and Federal users results in wireless system overloads, a decrease in signal quality, and disruption of service in the affected area. Additional factors contribute to diminished channel capacity of a wireless network, such as co- and adjacent-channel interference and the operation of multiple, independent, non-interoperable systems servicing the same geographical area, often using the same frequency bands and infrastructure (base station sites and towers). National security/emergency preparedness (NS/EP) planners and network operators must understand these interference effects to operate effectively in an overloaded environment.

Increasing demand for wireless voice and data communications requires that the limited spectrum resources allotted to PCS be used as efficiently as possible. Code division multiple access (CDMA) is a major wireless technology used in second generation cellular systems and is becoming even more prominent in third generation systems. Code division schemes make efficient use of allotted spectrum and are relatively unaffected by noise. The capacity of technologies using CDMA is limited primarily by co-channel interference. Most automatic power control schemes in PCS systems increase power levels when the level of interference is unacceptable. This increases the interference level for all users of a common frequency band and can cause an exponential effect where all users of the spectrum are at maximum power levels and experiencing a diminished Quality of Service (QoS). With the increasing dependence on code division technology, a clear understanding of the effects of interference is essential to increase the efficiency of spectrum use.

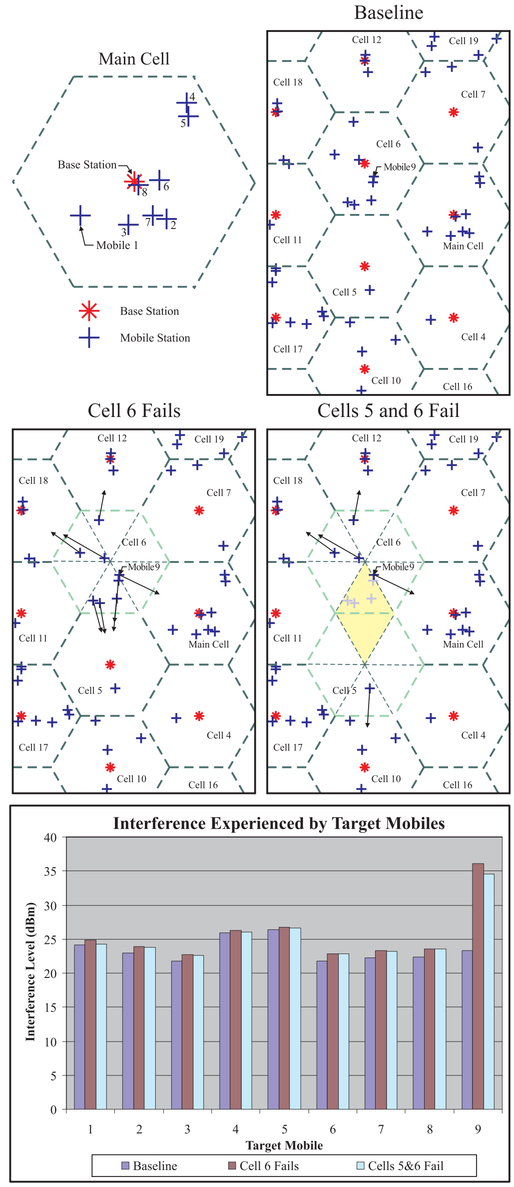
ITS has contributed to the understanding of inter-PCS interference by participating in the Telecommunication Industry Association (TIA) committee TR46.2 (Mobile & Personal Communications 1800-Network Interfaces). As a member of TR46.2, ITS contributed to the development of the Technical Service Bulletin "Licensed Band PCS Interference" (TSB-84A). This bulletin is a first step in characterizing the interfering environment caused by large numbers of active users and competing technologies. Since the completion of TR46.2's work, coverage of PCS interference concerns has been transferred to the Alliance for Telecommunications Industry Solutions (ATIS) subcommittee G3GRA (Radio Aspects of GSM/3G and Beyond), formerly T1P1.2. ITS continues to be involved in interference issues with this new group.

Detecting, identifying, and mitigating co-channel interference requires tools to characterize the interference experienced by PCS air-interface signals. PCS interference models are tools used to predict levels of interference and identify sources of interference. Several standard propagation models are accepted by industry members (i.e., Okumura and COST-231/Walfish/Ikegami) but no interference models have been developed or accepted. ITS is developing a series of PCS interference models starting with a model based on the ANSI/TIA/EIA-95-B standard, and leading to models covering proposed third generation (3G) systems. The model covers system-specific interference modeling to determine co-channel interference from both immediate and adjacent cells. It is based on the 95-B standard which produces a representation of an instantaneous 95-B air interface signal. The signal can contain outputs of multiple base stations with variable numbers of channels for each base station and can assign relative power levels for each individual channel. Both forward and reverse link processes are included in the model.

The input for the model is a sequence of binary values. This sequence can be random, but has no requirement to be random. For forward link signals, the appropriate Walsh code and orthogonal I and Q short pn codes spread the input sequence. For reverse link signals, the model modulates the input sequence with Walsh codes and then spreads the sequence with long and short pn codes. The resulting I and Q data streams pass through a baseband filter and a quadrature phase shift keyed (QPSK) or an offset QPSK (OQPSK) modulation scheme. The model calculates each channel signal contribution separately and then adds the processed signal to the other signal contributions to form a composite output signal. The power level for a single channel is an arbitrary gain factor of the baseband filter which is set separately for each channel. All the Walsh and pn code definitions come from requirements in the 95-B standard. The output of the model consists of a vector of numerical values representing a sampled QPSK or OQPSK signal. There is no error correction added to the input sequence, only spreading codes and modulation processes are used. This model does not check for recovery information contained in the input. Its only purpose is to determine how well the system can transmit the bits of the input binary sequence.

The output of the physical model is a sampled modulated signal which is the composite of the signals transmitted from all sources identified in a specified scenario. Software- and hardware-based simulations can use the sampled signal from the model to evaluate system designs. These simulations can characterize one-on-one, one-on-many, and many-on-one interference. As a result, potential solutions to congestion can be proposed to solve existing problems or to anticipate and avoid potential problems.

The figure displays a typical scenario showing the effects of system failure on the co-channel interference experienced by mobile stations in a cellular system. All cells in the system are populated by a single, centrally located base station, and a variable number of mobile stations which are randomly positioned within the cell. The main (center) cell contains eight mobiles, numbered as shown. Cell 6 contains eight mobiles, while cell 5 contains a single mobile. In the baseline state, all base stations are operating and are servicing their respective mobile stations. When the base station of cell 6 is removed, the mobiles of cell 6 are picked up by their nearest base station. In this situation, the main cell's base station picks up a single mobile (mobile 9), cell 5's base station picks up four mobiles, and the remainder are picked up by other surrounding cells. The plot shows the increase in co-channel interference experienced by the eight mobiles in the main cell, as well as mobile 9 whose service is transferred to the main cell. When the base station of cell 5 is removed, an assumption is made that the four mobiles that cell 5 picked up from cell 6 (those located in the yellow, diamond-shaped area) are no longer in position to receive service from any adjacent cell's base station. They are removed from service and no longer affect the interference levels of nearby mobiles. Cell 5's single mobile is picked up by its adjacent cell, and the interference levels for the nine mobiles being observed are recalculated. The plot shows the resultant change in interference. In most cases, interference is reduced due to the loss of the four mobiles that lost service. Mobiles 6 and 8 show almost no change in experienced interference due to their proximity to the main cell's base station.



Typical system load analysis scenario utilizing ITS' PCS co-channel interference model.

For more information, contact: Timothy J. Riley, (303) 497-5735 e-mail triley@its.bldrdoc.gov
or Teresa L. Rusyn, (303) 497-3411 e-mail trusyn@its.bldrdoc.gov